

Adaptive Tutorials Using Virtual Slides to Enhance Learning of Microscopic Morphology

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Abstract: Anatomy and Pathology require students to understand normal microscopic structure (histology) and appearances of disease (histopathology). For this purpose, we use Virtual Slides (VS) – browser-based virtual microscopy simulating use of a real microscope. However, in large practical classes using VS, teachers cannot assist every student who has difficulty with microscopic morphology. Thus, some students are not optimally engaged in learning with VS. To address this issue, we created online Adaptive Tutorials (ATs) that guide students through their interactions with VS. ATs are activities where feedback adapts to students' needs, based on their interactions with the tutorial. Analysis of students' interactions with ATs can permit refinement of feedback. ATs used in our Medicine program received high praise from students and teachers. There is also evidence of learning benefits for students. Such ATs could enhance learning in all disciplines that use microscopy.

Background

Many students find interpretation of microscopy problematic, but this is crucial to understanding structure and function of the body in health and disease. Anatomy and Pathology are highly visual disciplines, which require students to obtain an understanding of the normal microscopic structure of tissues (histology), as well as the microscopic appearances of diseased tissues (histopathology). One of the major barriers to learning in such disciplines is that students experience technical and practical difficulties in mastering the use of microscopes. This phenomenon can be attributed to high cognitive load due to the redundancy effect (Chandler and Sweller, 1991). Learning to use the microscope is a redundant task that is extraneous to the main goal of understanding the microscopic appearances, and how they relate to health and disease. Other problems encountered in such practical classes included: limited student-student and student-demonstrator interactions; high maintenance cost of microscopes and glass slides; limited opportunity for revision outside of scheduled class times; as well as variability in staining and content between slides i.e. no two glass slides are exactly the same.

Since 2002, we have progressively replaced microscopic examination of glass slides in histology/histopathology practical classes for both Medicine and Science students with computer-based virtual microscopy. That virtual microscopy creates an environment which supports student learning is now widely accepted (Kumar et al, 2004; Kumar et al, 2006). Other benefits that have been identified include image quality, speed and efficiency; and availability for self-directed learning. Virtual Slides are currently integrated into all Anatomy and Pathology courses at UNSW.

One barrier to learning with virtual microscopy in large practical classes (in each Medicine class we teach up to 140 students at 70 computer workstations) is that it is difficult for demonstrators to provide individual assistance to all students who have difficulty interpreting microscopic morphology. Further, Virtual Slides are only learning resources – unless engaging learning activities are built around them, students will not interact with Virtual Slides. Thus, despite its advantages over conventional microscopy, not all students are optimally engaged in learning with virtual microscopy. What is needed is some sort of guided interaction with the slides. Furthermore, without expert guidance, students' revision can be inefficient, leading to unremediated misconceptions. For those reasons, we have developed innovative online Adaptive Tutorials based on Virtual Slides.

Methods

Adaptive Tutorials are online educational activities where an Intelligent Tutoring System (ITS) models the student's level of knowledge in a domain. The ITS is then capable of adapting the activity's content, sequence of questions and feedback in response to a student's individual performance level. At UNSW, Adaptive Tutorials have been developed and are in use in many disciplines ranging from Music Theory to Mechanical Engineering, Physics to Biology and more. A description of the framework for creation of Adaptive Tutorials has previously been described by Ben-Naim, Marcus and Bain (2007).

For the purpose of teaching Anatomy and Pathology we incorporated Virtual Slide technology into Adaptive Tutorials. We thereby developed an environment within which students can be asked to answer questions and perform tasks that involve *interacting* with Virtual Slides, while being provided with individualised, adaptive remediation. Such interactions include: annotating, labelling, region marking and more. Appropriate interactivity has been shown to contribute to students' learning, motivation and engagement (van Merriënboer and Ayres, 2005), and enabling interaction in this domain is what makes this work unique and innovative. The adaptive online environment also supports guided exploration, which according to Kirschner, Sweller and Clark (2006), can lead to significant learning benefits.

Adaptive Tutorials can be flexibly utilised: in class or for later review; individual or collaborative use by students; as well as for formative or summative assessment. For example, students' conceptions of the relationship between microscopic structure and function can be efficiently diagnosed and, if necessary, remediated using these Adaptive Tutorials.

An example Adaptive Tutorial on Asthma is available to view at:
<http://www.adaptiveelearning.com/aelp/portal/unsw/pathology/asthma>

(Requires Flash Player 10 and best viewed at 1280x1024 or greater screen resolution)

Example screenshots from the tutorial are provided on the following pages (Figures 1, 2, 3 and 4).

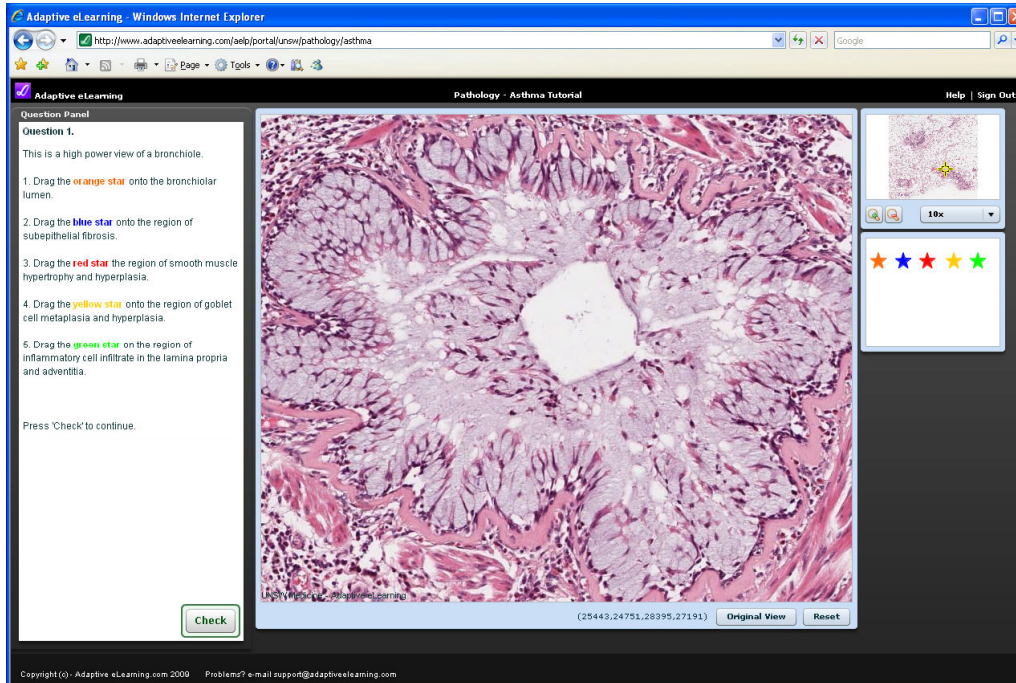


Figure 1: A question from an Adaptive Tutorial on Asthma requiring identification of salient features in an affected airway wall by dragging coloured markers onto the virtual slide.

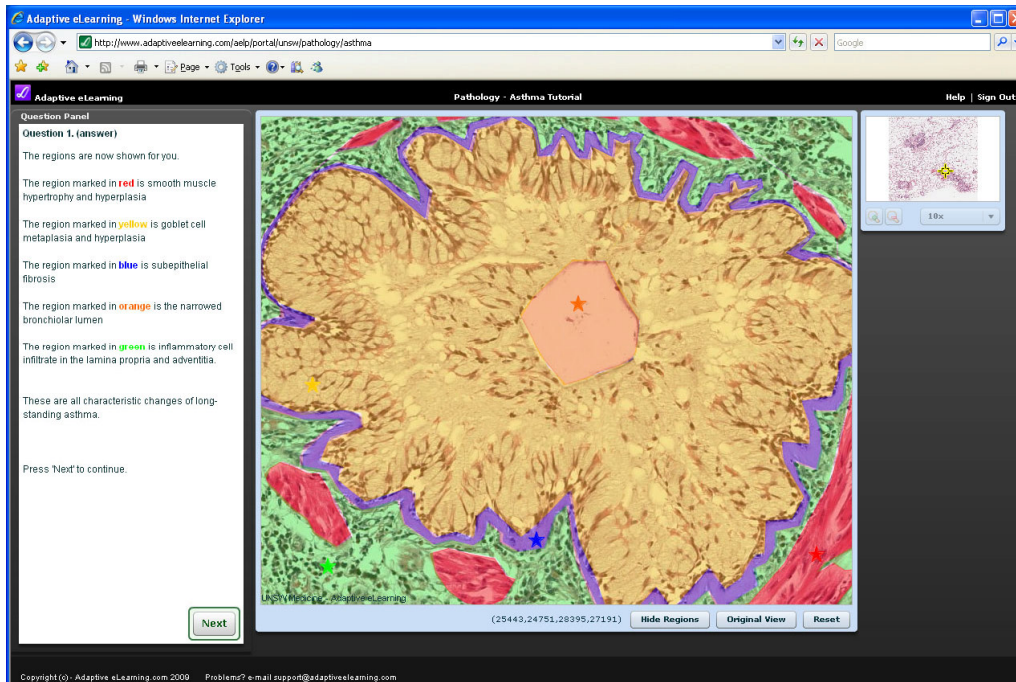


Figure 2: Structured text and visual feedback following a correct response to the question posed in Figure 1.

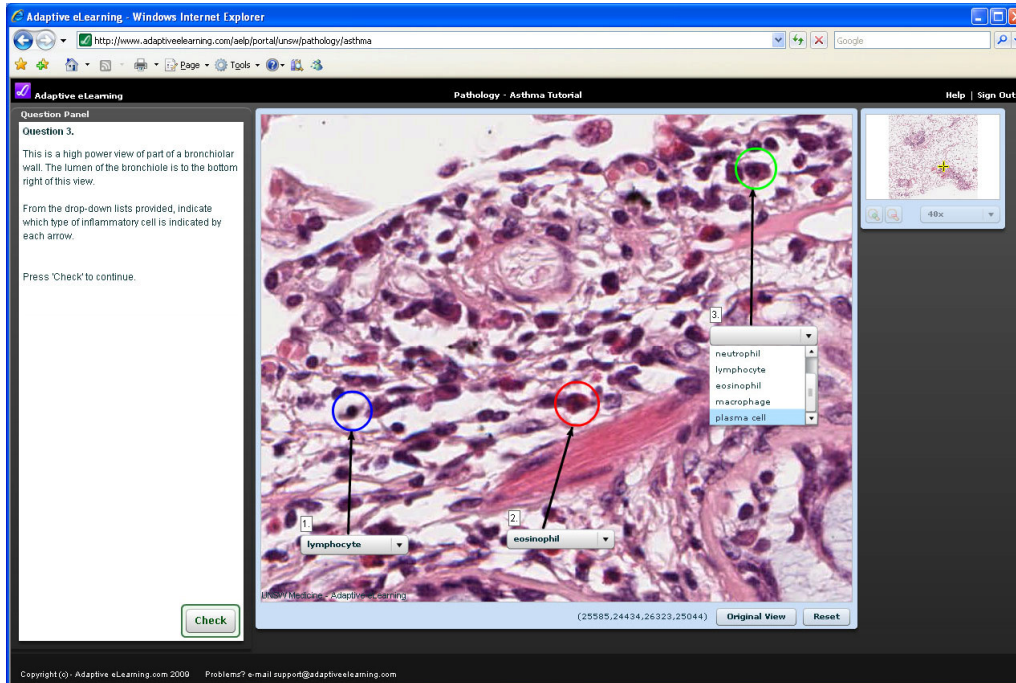


Figure 3: A question requiring identification of specific types of inflammatory cells in an airway wall in Asthma.

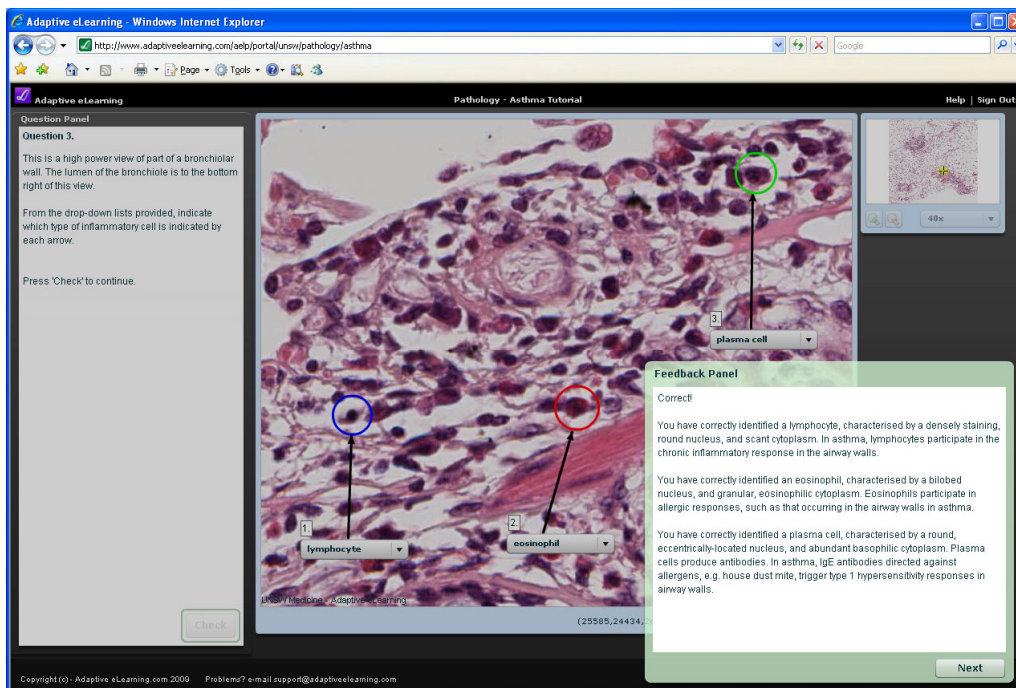


Figure 4: Structured feedback provided following the correct response to the question posed in Figure 3.

Results

Adaptive Tutorials were piloted in Phase 1 Medicine virtual microscopy classes (528 students over four iterations), with overwhelmingly positive responses from students and teachers. More than 90% of respondents found the adaptive exercises helpful, and wanted more to be made available. Greater than 80% of students perceived that they learned more from the adaptive exercises than from exploring Virtual Slides independently.

Results of a tailored online feedback survey (227 respondents, percent agreement in parentheses):

- a) Adaptive tutorials improved understanding (92.5%) – “*This would be a brilliant resource to refer to and use to deepen understanding. PLEASE make more of them!!!*”
- b) I would like to more Adaptive Tutorials in other practical classes (93.8%) – “*This was great, more of these would make learning histopathology fun and easy!*”
- c) I learned more from Adaptive Tutorials than from exploring virtual slides independently (90.7%).

There is also preliminary evidence of learning benefits from Adaptive Tutorials. In a Phase 1 Medicine practical examination in 2009, a cohort of 254 students scored significantly higher ($p < 0.0001$, Dunnett’s test) on a question related to a virtual slide on cerebral infarction (“stroke”), for which an Adaptive Tutorial was available. The other topics tested in the examination (virtual slides of asthma and metastatic cancer) were taught using “traditional” virtual slides. It should be noted that histopathology of the brain is traditionally considered to be difficult for students, lending weight to the notion that the Adaptive Tutorial on that topic made a significant difference to learning. Plans are already in place to develop Adaptive Tutorials for all Pathology practical classes in Medicine and Science programs.

Conclusions

While still in the early phases of implementation, Adaptive Tutorials based on Virtual Slides have the potential to revolutionise the teaching and learning of microscopy. Students’ learning can benefit from guided exploration of Virtual Slides with adaptive remediation. This has relevance not only to the disciplines of Anatomy and Pathology, but also Microbiology, Zoology and Botany. Wider use and controlled trials are required to fully explore the learning benefits of this innovation.

References

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